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NEW DATA ON THE EFFECT OF SUBPERMAFROST WATERS ON THE CAPACITY AND FLOW RATE OF THE INDIGIRKA RIVER

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The Indigirka River problem looked extremely complex following a systematic study undertaken after the October Revolution. It was found that this large river, with a drainage basin of 236,000 square kilometers,, freezes throught to the bottom in the middle course toward the end of the winter, while the rate of flow in the lower course does not exceed 15 cubic meters per second, dropping to 6 cubic meters per second in some years. This phenomenon was explained as follows: under the conditions of permafrost, "because of extreme cold in the soil, the existance of springs is either impossible or occurs but rarely"(3). This pointed to the conclusion that the Indigirka River has no permanent sources of ground water.

Yet the coefficient of flow was found to equal 4.4 liters per second per square kilometers. Such a large coefficient of flow does not correspond to the amount of precipitation in the river basin. Consequently, some hydrologists obtained negative values for moisture evaporation in the Indigirka River basin. They tried to find an explanation for the phenomenon in condensation of water vapor from the air, in extremely low evaporation, in good conditions of flow for atmospheric water, and in thawing of permafrost.

In a recently published article (5), the author attempted to prove by analysis of data at his disposal the similarity of conditions for condensation of evaporation in the Indigirka's upper and middle course and in the Yakutsk region. However, in the Yakutsk region a fast and steady drying up of lakes is observed, proving an excess of evaporation over precipitation. The author would not consider as a decisive factor the indication that in the Verkhoyanskiy Khrebet and Cherskiy Khrebet (mountain ranges) area the precipitation is from three to five times greater than in the middle course of the Indigirka River. A sharp difference in the thickness of the snow blankets on the southern and the northern slopes of Verkhoyanskiy Khrebet was established through observations made by V. P. Sedov in 1939. For that reason the Verkhoyanskiy Khrebet was regarded as a major barrier to penetration of air masses rich in precipitation into the Indigirka River basin.

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The conclusion drawn was confirmed by meteorological data. [illegible] mountain pass on the southwestern, Aldan side, in 1963, the precipitation rate was 535.4 millimeters, while the precipitation rate was [illegible] on the northeastern, Indigirka, side, though the latter is higher [illegible] by 500 meters. This fact explains the observed decrease in precipitation to 140 - 150 millimeters, on the Oymyakon side.

The Indigirka River differs from most of the great rivers of the northern part of Siberia in that the volume of summer flow is greater than the spring flow.

The author and V. P. Sedov (4) established a relation between (a) the gigantic layers of ice on the left mountainous bank of the Indigirka River and (b) the sources of superpermafrost waters which are related to the tectonic crevices, the crumbled, stratified formations of sedimentary rock, and the crystalline rock masses. On this basis, the above-mentioned article (5) concluded that, contrary to the prevalent opinion, the Indigirka River receives a considerable supply of water from subpermafrost sources, although this occurrence manifests itself in a very unusual way. During the 6 or 7 winter months the subpermafrost water of most of the sources provides for the growth of gigantic ice fields almost reaching the Indigirka River and its tributaries. Thus, natural, huge reservoirs of water are formed, bringing this water to the river only in the summer when the thaw sets in. Since these gigantic ice deposits may be counted by the hundreds in the Indigirka River basin, and since each one contains from one million to tens of millions of cubic meters of ice; they may yield some billions of cubic meters of water.

Such an approach would have clarified many obscure and contradictory points, but for one important stumbling block. According to A. F. Middendorf (3) -- the currently prevalent opinion -- most of the large deposits of ice of the Indigirka River basin are formed by river water of atmospheric origin. It should be pointed out, however, that observations and data to support this opinion are lacking.

During the past and winter we had a chance to visit the other regions of the Indigirka basin. While trying to discover the source for the gigantic layer of ice formed every year in the Moma River bed near its estuary, we came upon the source of a small river, the Taryn-Yuryakh ("layer of ice river"), which was ice-free on 13 November, appearing suddenly in the middle of a forest on the Moma River upper terrace at the foot of the steep slope of a third terrace 25 - 30 meters high. The Taryn-Yuryakh has neither a valley nor any drainage basin above the source. The stream, located at a distance of 6 - 7 kilometers from the Moma River bed, comes out of sand and pebble deposits on the upper terrace. Along with the water, multiple jets of gas gushed forth. The water temperature was 1.4 degrees, with the air temperature -35 degrees. At this time the Indigirka River at Moma settlement was covered with ice 50 - 60 centimeters thick, its water temperature going down to 0 degrees.

The flow of the Taryn-Yuryakh River measured with a hydrometric vane was 1.25 cubic meters per second. The water is fresh, containing not more than 100 milligrams per liter of dissolved salts -- less than the water of the Indigirka. The pH was 7.5 whereas that of the Indigirka River water was 6.95. The local inhabitants are correct in regarding the small river, and not the large Moma River, as the feeder of the ice layer, though the latter is located in the Moma River bed 10 - 12 kilometers from the Taryn-Yuryakh.

In the upper course area of the Moma River, 5 kilometers [illegible] from the river and the Sagyr settlement (Ulakhan-Chistay), at the foot of the Cherskiy Khrebet, at an altitude of about 750 meters above sea level and squarely in the middle of a forest, is the Ulakhan-Kyel'skiy spring water source, with a flow of more than 3 cubic meters per second, [illegible] connection whatsoever either with a river or with a drainage basin. Not only was the spring not frozen for a considerable distance, but the snow on its thawed banks was melting away. On 28 November the water temperature was 8.3 degrees centigrade with the air temperature -41 degrees centigrade. Even at 2.5 kilometers from the head of the spring, the water temperature was still above 6 degrees. Such a temperature for ground water in a region where the average yearly atmospheric temperature is 12 to 14 degrees and the temperature of superpermafrost ground water is 0.5 to 2.5 degrees even in summer, is extremely high and unusual.

Geologist S. S. Kolchin has reported that in the valley of the 26-kilometer-long Chalba River, which flows into the In'yali River, a left tributary of the Indigirka, there is a 25-meter-deep prospecting pit where he encountered a water-bearing level where the water temperature did not drop below 12 degrees centigrade with the air temperature at -50 degrees centigrade.

The waters of the above-mentioned Ulakhan-Kyel'skiy spring, whose temperature is 8.3 degrees, form, an entire river, without valley or drainage basin, flowing 10 - 12 kilometers into the Arga-Yuryakh River, where a gigantic layer of ice is formed.

In the middle course of the Yeyemyu River, a right tributary of the Moma, a layer of ice was discovered with an area of more than 4.5 square kilometers and containing more than 15 million cubic meters of ice toward the end of the winter. From the previous year's layer of ice there remained the edges and whole strips of ice 1.2 - 1.5 meters thick. To produce such an amount of ice during the seven winter months there must be a feeder with a flow of not less than 800 liters per second. The area of the Yeyëmyu basin upstream from the layer of ice is only 500 - 600 square kilometers.

A nonfreezing spring of ground water, with a temperature of 2.1 degrees centigrade when the air temperature was -27.4 degrees, was found upstream from the layer of ice. The spring flow was more than 500 liters per second on 20 November. Downstream from the layer of ice the river bed was dry; the autumn ice had caved in and the dry gravelly bottom could be seen through the cracks. But at the very mouth of the river there is another spring of ground water, with almost the same temperature and a flow of 558 liters per second, whose water is a source for the ice layer in the Ulakhan-Tayn.

In the Moma River bed upstream from the layer of ice there was an unfrozen patch of water. In order to determine the nature of the ice-free patch of water, a schematic survey of temperature was made. The water temperature of the Moma 400 meters upstream from the ice-free patch of water was 0 degrees; 100 meters upstream from the patch 0.3 degrees; at the upper end of the ice-free patch of water 7.1 degrees; in the middle of the patch 5.6 degrees; and at its lower end 4.8 degrees. The chemical composition of the water in the ice-free area was different from that of the Moma River water upstream where the ice was 25 - 70 centimeters.. The air temperature was -30 degrees centigrade on that day.

The springs of subpermafrost waters and gigantic layers of ice are numerous in the Moma River basin. Here we noted the largest and most typical ones, underlining especially the lack of connection with rivers in some of them.

The Kuydusunskiy spring was discovered in the Oymyakon region in the beginning of October. The water temperature was 5.2 degrees, the air temperature -5 degrees; the superpermafrost ground-water temperature 2.2 degrees; the water temperature of the Kuydusun River 1.3 degrees and the Buor-Yuryakh River water temperature 0.6 degrees. At the end of December, with air temperature -46 degrees, the spring was ice-free and from its issued clouds of steam. The upper part of the Indigirka River as shown by our observations on 12 December as well as by aerial photographs, abounds in ice-free springs and gigantic layers of ice.

The Nera River basin is typically an ice basin. According to exact data obtained by aerial survey, there are 13 gigantic layers of ice with an area of not less than 250 square kilometers. The mass of ice accumulating in these layers represents more than 500 million cubic meters. During the entire winter ice-free streams could be seen in the upper ends of most of the ice layers. Especially large ones are in the upper reaches of the Andygychan and Ken'myu rivers at an altitude of 800 - 1,200 meters.

In order to show how the gigantic layers of ice and their feeder-springs of subpermafrost water influence the volume of flow of the Nera River, we shall cite some hydrologic observations for 1944 - 1945. The average yearly flow 14 kilometers downstream from the mouth of the Andygychan River, with a drainage area of 21,750 square kilometers, was 139 and 146 cubic meters per second. It is greater than the flow of the Yana River at Verkhoyansk, with a drainage area of 75,000 square kilometers. The rate of flow is 6.4 - 6.7 liters per second per square kilometer; the volume of flow per annum is 4.38 - 4.60 cubic kilometers. The average yearly precipitation for the basin did not exceed 280 milimeters. The summer in the Nera River basin is hot (the average monthly temperature in July is 15 to 16 degrees), and evaporation would scarcely be less than 100 milimeters.(4).

Thus, the conclusion drawn corresponds fully with the opinion expressed by V. P. Sedov and the author in 1940 and 1941. (4) The gigantic layers of ice are the reservoirs of subpermafrost waters feeding the rivers of the Indigirka basin and controlling their flow. It should be added that the Indigirka River is characteristically similar to the rivers of glacial regions. The Indigirka River summer high water is of great importance to river navigation.

The region of the "Cold Pole" is also the region of the warmest spring of subpermafrost waters. In other parts of Northern Siberia -- for example, in Ust'-Yeniseyskiy Port, Yakutsk and Igarka -- the temperature of subpermafrost water never goes above 1.5 degrees, even at depths down to 800 meters.

This phenomenon can be explained by the difference in the character and age of the geologic structures of the given regions.

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